Method and Device in a Paper or Board Machine

The present invention concerns a method according to the
introduction to claim 1.

5

The present invention also concerns a device according to the
introduction to claim 9.

The method and the device according to the invention are
10   particularly suitable for determining the quantity and the
severity of defects in the form of shrinkage creases or other
types of crease in the web.

During the manufacture of a web of paper or board in a paper
15   machine or a board machine, and in particular during the
production of board from chemo-thermo mechanical pulp(CTMP), it
is not unusual that shrinkage creases, which extend along the
longitudinal direction of the web, form. The shrinkage creases
constitute an undesirable defect of the web that should be
20   reduced as much as is possible by changing the settings of the
board machine.

One method that is used to assess the appearance of the web and
the occurrence of shrinkage creases is to allow an operator to
25   inspect the web visually, for example during exchange of
machine roll, and to estimate the extent of the shrinkage
creases. The operator can, for example, estimate the extent on
a scale from one to three. There are, however, certain problems
associated with such a procedure. Firstly, the procedure is
30   subjective, i.e. there is a risk that different operators will
estimate the extent of the same shrinkage creases differently.
Secondly, the area of inspection is limited to that part of the
web that is visible at the machine roll, i.e. the part of the
web that forms the covering surface of the machine roll.
35   Thirdly, it is only possible to discover relatively major
changes in a visual inspection. In other words, the resolution
of a visual inspection is relatively low.

One way of objectively measuring the surface structure of a web of paper is described in the patent SE 516999. According to the method described, two images of the web are taken in the transverse direction of the web at a pre-determined position.

5    The web is illuminated for the two images by light obliquely incident from two different directions, i.e. the web is illuminated with light that is incident from a first direction during the taking of the first image, and it is illuminated with light incident from a second direction during the taking

10   of the second image. The images are subsequently Fourier-transformed and the spectra obtained are combined to give an approximation of the correct spectrum of the web. It has, however, become apparent that this method of measuring the surface structure of the web is less suitable when shrinkage

15   creases are present. In particular, the step of taking two images with illumination from two different directions is inconveniently complex.

The aim of the present invention is to achieve a method and a

20   device that are particularly suitable for determining in real time the quantity and the severity of shrinkage creases.

The method according to the invention is characterised by the characterising part of claim 1.

25

The device according to the invention is characterised by the characterising part of claim 9.

The invention will be described in more detail with reference

30   to the figures.

Figure 1 shows schematically and in principle a device according to one preferred embodiment of the invention.

35   Figure 2 shows a flow chart that illustrates one preferred sequence of steps in order to determine the quantity and the severity of shrinkage creases according to the invention.

Figure 3 shows an image of a surface section of a web of board that demonstrates shrinkage creases.

Figure 4 shows the image according to Figure 3 following an
5   image processing step according to the invention.

Figure 1 shows a device for determining in real-time the quantity and the severity of shrinkage creases that form in a web 1 of board when the web 1 is manufactured in a board
10   machine (not shown in the figure). The device comprises an imaging system, which comprises a camera 2 in the form of a digital CCD camera of the type known as "progressive scan". The camera 2 is arranged above the web 1 and is directed towards a pre-determined area 3 of the web 1, in which area 3 it is
15   desired to analyse the surface structure of the web 1. In the present case, the area 3 is located at one edge section of the web 1. The imaging angle of the camera 2 and the distance between the camera 2 and the web 1 are chosen such that it is possible for the camera 2 to image in the said area 3 a surface
20   section 4 of a pre-determined size of the web 1 when the web 1 passes in front of the camera 2. The device further comprises an illumination system, which comprises a lamp 5 arranged at a pre-determined position above the web in order to illuminate the area 3 with obliquely incident light. The position of the
25   lamp 5 in the present case is at the same height as the camera 2 in the longitudinal direction of the web 1, and the axis of illumination of the lamp 5 forms an angle with the web 1 that lies in the interval 1-15°. The lamp 5 can, however, be placed at another position that provides illumination of the area 3
30   with obliquely incident light. It is preferable that the lamp 5 comprises a xenon incandescent lamp that provides the required light intensity in a suitable wavelength interval. Other light sources can, however, be used. The device also comprises an image processing system, which comprises a computer 6.
35

A preferred sequence of steps of determining the quantity and the severity of shrinkage creases using the device described above will be described below with reference to Figures 2-4.

The initial step is an image capture step 7 in which the camera
2 is caused to capture a pre-determined number of images of the
web 1 in the light from the lamp 5 as the web 1 passes in front
of the camera 2. The images thus form an image sequence that
5       represents a series of surface sections 4, 4', 4", ... along a
band 8 in the web 1. A suitable sequence of images may, for
example, consist of 50 images taken during a duration of 2
seconds. Figure 3 shows an illuminated surface section from
such a sequence, which surface section extends vertically in
10      the figure approximately 0.200 metre along the longitudinal
direction of the web and horizontally in the figure
approximately 0.267 meter in the transverse direction of the
web 1. The camera 2 has in the present case imaged surface
sections such as a digital image with a height of 580 pixel
15      lines and a width of 770 pixel columns. Shrinkage creases
appear in Figure 3 as dark bands that have an extent in the
longitudinal direction of the surface section, i.e. vertically
in Figure 3.

20      The images are transferred to the computer 6 after the image
capture step 7, whereby an evaluation step 9 commences. The
evaluation step 9 comprises a preparative image processing step
10 and a subsequent image analysis step 11.

25      The computer 6 carries out a sequence of image operations on
each of the images during the image processing step 10. The aim
of this step is to reduce contributions from disturbing sources
of error, such as, for example, irregular and varying
illumination, and to prepare the images for the subsequent
30      image analysis step 11. A first image operation 12 comprises
the division of each pixel value in each image with the mean
pixel value of the image, after which each pixel value is
multiplied by a pre-determined factor, for example 100. A
second image operation 13 comprises the cropping of the edges
35      of the image such that the image obtains pre-determined
dimensions. The rectangle in Figure 3 indicates such a cropping
operation, in which the cropped image has a height of 470 pixel
rows and a width of 512 pixel columns. A third image operation
14 comprises the division of the image into groups along the

longitudinal direction of the web 1 with a pre-determined
number of consecutive pixel rows in each group, after which new
pixel rows are formed through the calculation of the mean value
of the pixel values in each pixel column in each group and the
5    assignment of this mean value to the pixels in the new pixel
row. A fourth image operation 15 comprises the high-pass
filtration of the image in the transverse direction. It is
preferable that the high-pass signal is calculated through the
subtraction from the original image of a low-pass signal
10   obtained, for example, by causing an FIR Blackman filter to
operate on the image. Figure 4 shows the image according to
Figure 3 after the image operations specified above, where
there are formed 47 groups with 10 pixel rows in each group
during the third image operation, after which 47 new pixel rows
15   are formed through the calculation of the mean value of the
pixel values in each pixel column in each group and its
assignment to the pixels in the new pixel row. Figure 4 makes
it apparent that the visible uneven illumination seen in Figure
3 has been reduced through the image operations. Thus, a series
20   of images is obtained from the image processing step 10, which
in the present case has a height of 47 pixel rows and a width
of 512 pixel columns, in which contributions from disturbing
sources of error have been reduced.

25   The image analysis step 11 commences after the image processing
step 10. The image analysis step 11 comprises a first analysis
operation 16, in which the variance of the pixel values in each
pixel row in each image is calculated within a pre-determined
spatial wavelength band. This analysis operation 16 preferably
30   takes place through the Fourier transformation of each pixel
row with the aid of an FFT algorithm, after which the variance
within the pre-determined band of wavelengths is calculated.
Thus, this Fourier transform is one-dimensional. It has become
apparent by comparing the visual ranking results using various
35   wavelength bands that a wavelength band comprising the
wavelengths 0.7-4 mm correlates well with the irregularities
that shrinkage creases cause in board. Other wavelength bands
may be relevant for paper. For example, a wavelength band
comprising 3-15 mm has proved to be suitable for irregularities

that folds in fine paper cause. The image analysis step 11
further comprises a second analysis operation 17, in which the
mean values of the variance of all pixel rows for all images in
the series are calculated and displayed on a monitor or stored
5    for future evaluation. This mean value of the variance
constitutes a measure of the quantity and the severity of
shrinkage creases in the web 1, and an operator can rapidly and
easily see trends in shrinkage creasing by comparing the mean
value of the variance with results from previously evaluated
10   image sequences, and take suitable measures.


Shrinkage creases can occur over the complete width of the web,
but they occur principally at the edge sections of the web. It
is therefore preferred that a device according to the invention
15   is directed towards one edge section of the web, as is shown in
Figure 1. It will, however, be realised that the arrangement
can comprise several imaging and illumination systems that are
directed towards different parts of the web. For example, one
imaging system and the associated illumination system can be
20   directed towards the second edge section of the web, and an
imaging system and its associated illumination system can be
directed towards the central section of the web. It is thus
possible, by using an arrangement comprising several pairs of
imaging systems and illumination systems, to determine in real-
25   time the quantity and the severity of shrinkage creases across
the complete width of the web. Alternatively, one pair of an
imaging system and an illumination system can be arranged such
that it is possible to traverse across the web, and in this way
the same imaging system can be used to image different parts of
30   the web or the complete web. The imaging systems and the
illumination systems can be arranged above the web, below the
web, or both above and below the web.


One preferred sequence of steps for determining the quantity
35   and the severity of shrinkage creases in a web has been
described above. It will, however, be realised that the imaging
and analysis operations described can be varied within the
framework of the invention. Certain operations can be omitted
or can be modified and other operations can be added without

the deviating from the principle of the invention. It will also
be realised that those parts that are included in a device
according to the invention can be varied without deviating from
the principle of the invention. For example, a linear recording
5   CCD camera can be used instead of the said camera of
"progressive scan" type. In such a case, the said images would
be constituted by several lines, which form a sequence that
images a surface section along a band in the web.